Workshop Nuclear Power Growth: Proliferation Resistance and Physical Protection

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I am very concerned about climate change. We may not be able to stabilize greenhouse gas concentrations at acceptable levels without a very large expansion in nuclear power—by a factor of at least four or five over the next 50 years.

But the only thing that I worry about more than climate change is possibility that nuclear weapons will spread to additional states or even to terrorists, and that one will be detonated in a city.

Using current fuel cycle technologies and under current institutional arrangements and agreements, I'm worried that a large-scale expansion of global nuclear energy production would substantially increase risks of nuclear proliferation and nuclear terrorism. And so I welcome discussions, such as this one, to explore how we might reduce these risks.

One important difficulty is that we have no widely accepted method or metric of evaluating proliferation resistance. The contrasts with the area of nuclear safety, where fault tree analysis is widely used to produce estimates of the safety of reactors and other nuclear facilities. I am aware of attempts to apply similar approaches to proliferation resistance. I probably shouldn't comment on the likelihood of success without becoming more familiar with what has been done, but it would seem that any quantitative measure of proliferation resistance will inevitably be based on many assumptions for which there is no empirical evidence. The other basic difference is that, in proliferation resistance, one is dealing with an intelligence adversary who can adapt to whatever measures are adopted. The estimated probability that a pump or value will fail can be based on observation, but the probability that an intelligent state or a terrorist group will attempt a particular diversion scenario and succeed cannot, and assumptions are likely to vary substantially between countries. A cautionary tale is the attempt by Russia's Kurchatov Institute, about ten or so years ago, to measure the proliferation resistance of various fuel cycle options. They concluded that fuel cycles involving large quantities of natural uranium were worst, because natural uranium was most vulnerable to undetected diversion, and therefore that a closed breeder fuel cycle was best.

It goes without saying that improved safeguards and physical protection will play an important role in improving proliferation resistance. I co-authored an APS report some years ago that noted the low level of funding for safeguards R&D, both in the U.S. and elsewhere, and called for a a robust R&D program to develop new technologies to prevent and detect the misuse or diversion of sensitive nuclear technologies and weapon-usable nuclear materials.

But I think there is a prior fork in the road, and that concerns the acceptable uses and ownership of sensitive nuclear technologies and materials. The current international understanding is that peaceful uses are permitted so long as they are safeguarded. The nuclear suppliers group may restrict exports of sensitive technologies, but as we've seen with North Korea, Iran, Brazil, Libya, indigenous development or covert acquisition as possible.

When enrichment and reprocessing facilities or stocks of high-enriched uranium (HEU) and unirradiated plutonium exist in a country, we've lost 90 percent of the battle. Such a country is already a virtual nuclear weapon state, and could break out and produce a weapon in weeks or months (assuming the weaponization work had already been done)—far too short a time to permit an effective response by the international community.

Better safeguards for enrichment? Absolutely—we can do better to detect in a more timely manner a diversion of separative work or enriched uranium. But we can already detect whether a facility has ever produced HEU. The bigger problem is to prevent breakout, either using a declared or clandestine facility. More important than better safeguards for declared facilities is better technology to detect clandestine facilities. But most important of all is to restrict knowledge and ownership and location of enrichment technology as much as possible. The Global Nuclear Energy Partnership (GNEP) calls for that through voluntary fuel supply guarantees, but I think it's apparent that this won't work—unless it is coupled with spent fuel take-back.

But it doesn't matter what we do with the spent fuel after we take it back. The assumption underlying GNEP is that separation and transmutation (S&T) in fast reactors will make take-back more acceptable politically. But I do not agree. Transmutation does not eliminate nuclear waste—you still need a repository, and so the political barriers to waste disposal need to be resolved with or without transmutation. And I have never heard a satisfactory explanation of the economics of separation and transmutation. There are only two possibilities: either S&T will be more expensive than once-through light-water reactors (LWRs), or it will be cheaper. I think it will be more expensive; if it is, who will pay the premium, which could amount to many billions of dollars per year? The user countries? The supplier countries? But if fast reactors are cheaper than LWRs, how will we deny the use of this technology by all countries?

I think it would be more productive to put far more effort into the international storage and disposal of spent fuel and other high-level waste.

Better safeguards for reprocessing? Absolutely. Using current safeguards technology, we are not able to meet IAEA goals for the detection of the diversion of a significant quantity of plutonium from a large reprocessing plant in a timely manner. But it would be far better to restrict knowledge and ownership of the technology as much as possible, and to build and operate reprocessing facilities and reprocess spent fuel only when there is a compelling reason to do so. GNEP moves is the wrong direction by reversing long-standing U.S. policy opposing reprocessing, without a compelling reason. The GNEP concept of developing proliferation-resistant reprocessing is particularly unhelpful. Keeping plutonium mixed with transuranics does not make it proliferation resistant. We wouldn't want a country of proliferation concern to have such a plant because it could be modified to produce pure plutonium, and we wouldn't want countries of concern to use transuranic fuels because the plutonium could be separated in a glove box. Indeed, separation processes that result in transuranic product promise to complicate the material accounting problem and make it even more difficult to meet goals for the timely detection of diversion of weapon-usable material.

Better physical protection for nuclear materials? Absolutely. Stocks of unirradiated or lightly irradiated HEU and plutonium should be subject to the highest standards of material accountancy, control, and protection—the same standard applied to intact nuclear weapons in the United States. We should have international standards for physical protection, including the development of design-basis threats and red-team exercises that are subject to international scrutiny and accountability. But physical protection depends on the integrity of the host government and its security forces, and will be vulnerable to weakening or collapse of the government. It would be far better to eliminate the use of HEU entirely—a high priority program to convert all research reactors to LEU, to buy up and blend down all stocks of HEU in non-weapon states, and to eliminate excess stocks in weapon states. Similarly, plutonium fuels should be used only when there is a compelling need, and any use or transport of Pu should be according the same level of physical protection as that given to nuclear weapons in the U.S.

Finally, proliferation resistance is often approached as something measured or added on after the fact. Various countries and companies have had preferred reactor and fuel cycle options, and they compete rhetorically to assert that one is better than the other, or we try to figure out ways, like fuel banks or UREX, to try to make them more proliferation resistant.

I would like to see more effort to use proliferation resistance as the main design principle for fuel cycle alternatives, starting with a clean sheet of paper. I think that would lead to options for small reactors with long lifetime cores, such as the Atoms for Peace Reactor concept developed at PNL. To be economically successful, such reactors would have to be mass produced, which holds out the possibility that all fresh fuel production and spent fuel handling would be naturally concentrated in the hands of a few producers. Small reactors are on the GNEP PPT slides, but so far no money has been allocated. This is the sort of initiative that I hope DOE might take up seriously under the next administration.